WETLAND FUNCTIONS AND VALUES

Wetland Evaluation Technique (WET)

Nine functions and two uses/values were evaluated. Per Carney 2002, the WET method is defined as a broad brush approach to wetland evaluation based on correlative predictors of wetland function that can be assessed relatively quickly. In this method, a number of observations and measures are made to assess the **existing level of support, opportunity to support, or potential to support a given function.** A sub-set of these observations and measures for each function based on the scope of work and time available at each wetland during the project. Some predictors are better than others, and were identified in the WET methodology as being of low, moderate, or high value in predicting the level of function. These weights were also factored into the overall scoring of wetland functionality. Depending on the function and associated observation parameter, a predictive value was assigned for each and noted as low, moderate, and high as shown:

Low predictive value: 1, 2, 3

Moderate predictive value: 1, 3, 5

High predictive value: 1, 4, 7

Each observation parameter was then assigned a low, moderate, or high score (e.g., 1, 2, or 3, or 1, 3, or 5, or 1, 4, or 7 depending on which predictor value the parameter was assigned.

Groundwater Recharge

Definition: Rate of recharge or movement downward of surface water exceeds that of discharge (movement laterally or upward of groundwater).

Effectiveness

Rationale (HIGH). Set of conditions for **HIGH** probability of GW recharge in a precipitation deficit climate:

- Not permanently flooded
- Have a negative discharge differential or
- Have an inlet but no outlet
- And not be a fringe wetland

Rationale (LOW). Set of conditions for **LOW** probability of GW recharge in a precipitation deficit climate:

- All marine and estuarine wetlands
- All wetlands with impervious underlying strata
- All non-fringe AAs that have outlets only
- Other wetlands that do not have <u>all</u> of the following: coarse underlying strata, not below a dam, and no indicators of GW discharge

General Sensitivity
Relatively more western will receive HIGH ratings. With the lack of in situ data or knowledge, pivotal factors include hydroperiod, precipitation balance, contiguity, and system predictors.

Observation Parameters for Groundwater Recharge Function

Local topography (1-3-5)—often the slope of the water table parallels the topography of the land surface, so GW is more likely to occur in situations where the topo relief is characterized by a sharp downslope away from the wetland.

Presence of inlets/outlets (1-3-5)—a wetland with a permanent inlet but no outlet is more likely to recharge water. A wetland with neither outlet nor inlet is intermediate in recharging.

Wetland system classification (1-4-7)—palustrine, lacustrine, and riverine systems are more likely to recharge GW than marine and estuarine systems. Riverine has more potential than other two, but lack sufficient vertical head annually.

Watershed land cover (1-3-5)—wetlands in watersheds of mostly impervious surfaces more likely to recharge GW than alternative wetlands.

Presence of ditches/channels (1-3-5)—wetlands without these features are more likely to recharge wetlands than those with.

Soil permeability (1-4-7)—soils with permeable soils or karst features are more likely to recharge GW. Furthermore, wetlands in watersheds dominated by soils with slow infiltration rates are also more like to recharge GW.

Water level controls (1-2-3)—wetlands created by a dam and located below it are more likely to recharge GW.

Flooding extent/duration (1-3-5)—wetlands with extremely variable water levels or unstable flow are more likely to recharge GW that those with very stable water levels. Expanding water along surface more likely to cover unsaturated soils during flood events.

Water quality anomalies--WQ data (1-2-3)—WQ levels showing drastically reduced TDS, halinity, alkalinity, conductivity and/or hardness, with increased prevalence of bicarbonates or sulfates of calcium or magnesium are more than likely indicative of GW recharge.

Water temperature anomalies--WQ data (1-3-5)—wetlands with drastic natural thermal anomalies (GW cooler in summer and warmer in winter) would likely be indicative of GW discharge.

Groundwater Discharge

Rate of discharge from groundwater (deep or shallow) into the wetland exceeds the rate of recharge to underlying ground water from the wetland on a net annual basis.

Effectiveness

Rationale (HIGH). Numerous sets of conditions for HIGH probability of GW discharge including most permanently flooded or saturated wetlands that are:

- In precipitation deficit regions
- Immediately below dams
- Larger than 200 acres, with a watershed less than 5 times the area of the assessment area
- Larger than 200 acres and not surrounded by paved land
- Steeper gradient downstream of the outlet than upstream of the inlet
- Lacking inlets but having outlets, and not dominated by snowmelt (non-fringe wetlands only)
- Stable with regard to seasonal water-level fluctuations, or
- Characterized by springs, water quality, or temperature anomalies that suggest discharge

If the wetland is not permanently flooded or saturated, a rating of HIGH may still be assigned if at least two of the above are met.

General Sensitivity
A majority of wetlands nationwide will probably attain ratings of HIGH especially if they are *permanently flooded*. See previous discussion for most pivotal predictors.

Observational Parameters for Groundwater Discharge Function

Watershed/wetland ratio (1-2-3)—a large wetlands with a proportionately small watershed may indicate water budget subsidization by GW discharge. And as the wetland/watershed ratio increases probability of GW discharge also increases.

Local topography (1-3-5)—when topographic relief can be characterized by a sharp downslope towards the wetland and/or the wetland is located near a geological fault or at the base of a local horizontal gradient of decreasing soil permeability.

Presence of inlets/outlets (1-3-5)—wetland with a permanent outlet and no inlet more like to discharge GW than one with other combinations of inlets and outlets.

Vegetation class/subclass (1-2-3)—riverine wetlands dominated by mosses and liverworts (or fen species) are more likely to discharge GW.

Watershed land cover (1-2-3)—wetlands with unpaved watersheds more likely to allow GW discharge to occur.

Presence of ditches/channels (1-3-5)—wetlands without ditches, channels, levees, and similar artificial features are more likely to discharge GW than altered wetlands.

Hydroperiod (spatially dominant) (1-2-3)—nontidal wetlands with hydroperiods such as permantently flooded, intermittently exposed, and saturated, artificially flooded are more likely to discharge GW.

Water level controls (1-2-3)—wetlands influenced by upstream impoundments are more likely to discharge GW that those no influenced by such impoundments.

Flooding extent/duration (1-3-5)—wetlands that have stable water levels and flows more likely to recharge GW than those with unstable conditions.

Water quality anomalies--WQ data (1-3-5)—Wetlands with drastically elevated carbon dioxide, TDS, alkalinity, hardness, halinity, conductivity, and/or chlorides, sulfates, or bicarbonates of sodium, iron, or manganese are more likely indicative of GW discharge.

Water temperature anomalies--WQ data (1-3-5)—wetlands with water temperatures that drastically differ from ambient are more likely to discharge GW.

Floodflow Alteration

Definition. Occurs in those areas where surface water is stored or its velocity is attenuated to a greater degree than typically occurs in terrestrial environments. No judgment is made as to the value of such flow alteration.

Effectiveness

Rationale (HIGH). There are five types of AAs that most clearly are effective in altering floodflows, including those which:

- Have regulated outflows (e.g., reservoirs and dams)
- Have outflows that are measured as being less than inflows
- Have neither an outlet nor an outlet
- Expand their surface area by at least 25 percent for 20 days of the year and are larger than 5 acres, or
- Are larger than 200 acres and are either in a precipitation deficit region or (if flowing water is present) are at least 705 covered with justaposed woody vegetation.

Consequently, the simple presence of vegetation which adds to channel roughness is considered insufficient to result in a rating of HIGH; the wet depression must remove (through evapotranspiration) or store water as well as create a lag (desynchronized) effect.

Rationale (LOW). Wetlands with LOW probabilities of altering floodflows are assumed to be those which has **all** of the following characteristics:

- Spatially dominant hydroperiod is ‘permanent’
- AA is less than 200 acres
- No potential for ponding of stormflows is apparent (e.g., fringe wetland or others with unconstructed outlets)
- If precipitation is greater than evaporation, and the AA is smaller than 5 acres
- If flow is present, channels are neither sinuous nor contain ample woody vegetation to intercept surface flows.

General Sensitivity
Most western and prairie wetlands will be rated HIGH as will large flowing wetlands elsewhere with extensive woody vegetation. LOW ratings will be assigned to most small, unconstricted, permanently flooded wetlands in the east especially if they lack low-gradient channels and woody vegetation. MODERATE ratings will be the most common rating in many regions. Ratings do not reflect the quantity (e.g., acre-feet) of flood storage, only the probability that storage or loss will occur or lag time will be measurably increased. Pivotal predictors are wetland type, region, contiguity, size, and vegetation form.

Opportunity

Wetlands lower in a watershed may have a greater opportunity for intercepting floodflows, but if they are lower in the watershed than most floodable properties their social significance and often their effectiveness may be less.

Wetlands with highest opportunity for floodflow alteration are those that are not tidal and have a large watershed relative to their size OR those watersheds that are primarily urban or relatively impervious soils, with few storage opportunities upstream. Wetlands with the lowest opportunity are those in the HIGH rating plus have a small watershed relative to the wetland size, predominantly forested landcover in the watershed and upstream storage areas.

Observational Parameters for Floodflow Alteration

Climate (1-4-7)—wetlands located in precipitation-deficit regions more likely to alter floodflows than those in more humid regions as wetlands typically with lower water levels will store more flood water.

Wetland area (1-4-7)—the ability of a wetland to alter floodflows depends on its storage capacity and hydraulic length, which are determined by its area, depth, and sediment type. Note: position in watershed and geomorphic characteristics are also important.

Watershed/wetland ratio (1-4-7)—wetlands with watersheds that contain little wetland area above the wetland of interest, or those with a large watershed in relation to the wetland, are most likely to have the opportunity for floodflow alteration.

Presence of inlets/outlets (1-4-7)—wetlands without outlets are more likely to alter floodflows than those with outlets.

Constriction of outlet (1-4-7)—wetlands with an unconstricted inlet and a constricted outlet are more likely to alter floodflow than those with unconstructed outlets.

Wetland system classification (1-4-7)—Riverine (tidal), estuarine, and marine systems are less likely to have an opportunity (and be effective at) altering floodflows.

Fringing wetland (1-3-5)—Fringe wetlands and those associated with islands are less likely to alter floodflows. Vegetation needs to be wide enough to intercept water flow.

Vegetation class/subclass (1-3-5)—Wetlands with forested or scrub-shrub vegetation are more capable of altering floodflows than are aquatic bed, moss, or emergent wetlands.

Vegetation/water interspersion (1-3-5)—this function depends on two factors: 1) the amount of interspersion of vegetation present and 2) the type of water flow through the wetland. Essentially, wetlands with dense stands of vegetation with little interspersed open water are more likely to alter floodflows.

Sheet vs. channel flow (1-3-5)—Wetlands where water occurs as sheet flow are more likely to alter floodflows than those where water occurs primarily as channel flow.

Watershed land cover (1-4-7)—wetlands in watersheds with mostly impervious land cover are more likely to have the opportunity for floodflow alteration than those in watersheds that are predominantly forested or shrubby.

Presence of ditches/channels (1-4-7)—wetlands having hydrologic alterations that cause water to leave faster than originally occurred are less likely to alter floodflows significantly.

Soil permeability (1-3-5)—Watersheds with mostly impervious soils provide wetlands with proportionately more runoff and thus greater opportunity alteration. Increased runoff provides greater opportunity for wetlands to alter floodflows. Also, wetlands most likely to be effective at altering floodflows have soils with rapid infiltration rates.

Water/vegetation proportions (1-4-7)—wetlands with a high proportion of vegetation coverage will be more capable of altering floodflows. Vegetation slows floodwaters and wetland zones without permanent standing water are important due to the vegetative resistance but also the unsaturated sediments more than likely present.

Hydroperiod (spatially dominant) (1-4-7)—wetlands without permanent standing water are more likely to alter floodflows than are permanently inundated wetlands.

Flooding extent/duration (1-4-7)—wetlands capable of expanding their surface water acreage substantially and for long periods of time are more likely to alter floodflows through the retention of floodwaters.

Sediment Stabilization

Definition. HIGH sediment stabilization areas are those which are more effective for binding soil and dissipating erosive forces than are typical upland environments.

Effectiveness

Rationale (HIGH). Wetlands rated HIGH for this function must be characterized by one of the following characteristics:

- Potential erosive features present
- Unsheltered or Zone C greater than Zones A and B
- Ditches, canals, or levees are present that confine water
- High water velocity
- Evidence of long-term erosion, or

- Water table influenced by an upstream impoundment.

Also, one of the following characteristics must be present:

- Rubble substrate
- Protective of nearby shorelines
- Greater than 20 foot width of erect vegetation
- Presence of forest of scrub-shrub vegetation, or
- Good water and vegetation interspersion

Rationale (LOW). Wetlands rated low have no flowing water, no boat wakes, no open water wider than 100 feet, and no eroding areas abutting the wetland as well as no vegetation (erect or submerged) or rubble.

General Sensitivity
Marine, estuarine, riverine, and contiguous palustrine wetlands will never be rated LOW by these criteria. Most vegetated estuarine and palustrine wetlands with some open water will be rated HIGH as will most rocky seacoasts and islands. Pivotal predictors are those dealing with contiguity, flow, fetch, and vegetation zone width.

Observational Parameters for Sediment Stabilization

Gradient (1-4-7)—wetlands having steep gradients are more likely to have an opportunity to stabilize sediments. Steeper gradients imply greater velocities, greater erosiveness, and greater erosion potential.

Vegetation class/subclass (1-3-5)--Wetlands with predominantly forested or scrub-shrub vegetation are more likely to stabilize sediment than those with predominantly aquatic bed vegetation.

Vegetation interspersion (1-4-7)—Wetland with dense, extensive stands of vegetation are more likely to contribute to sediment stabilization than are those with no vegetation. Root of wetland vegetation anchor wetland soils, reducing erosion. Wetland plants also reduce flow velocities and rapid wave action, thus reducing potentially erosive forces. Therefore, the denser and more extensive the vegetation (i.e., lower interspersion), the more likely the vegetation will stabilize sediments.

Sheet vs. channel flow (1-4-7)—wetlands where water enters a channel and then spreads out over a wide area are more likely to stabilize sediments.

Fetch/exposure (1-3-5)—Wide fetch (e.g., length of water over which a given wind has blown) provides greater opportunities for wave generation; wetlands that intercept waves and thus protect nearby shores are more likely to stabilize sediment. Wind direction and water depth are important interrelated factors, but difficult to assess from one visit.

Flowing water (1-4-7)—Wetlands with flowing water are more likely to have an opportunity to stabilize sediment. Evidence of scouring indicates a greater opportunity for sediment stabilization, too.

Presence of ditches/channels (1-3-5)—Wetlands having modified distributaries that allow surface waters to flow at a faster rate are likely to have a greater opportunity to stabilize sediment.

Sediment sources (1-4-7)—Wetlands surrounded by potentially erosive conditions are more likely to have an opportunity for sediments to be stabilized. Documentation of potentially erosive conditions such as drastic water level fluctuations, steep slopes, frequent boat wakes, channelized tributaries, etc. that significantly elevate suspended solid levels.

Vegetation/water proportions (1-4-7)—Wetlands having no robust vegetation in zones where surface water occurs are less likely to stabilize sediment. Stem and root volume is a better measure than percent cover; water depth is also a key factor.

Water level controls (1-4-7)—Wetlands located just downstream from large impoundments (higher than 20 feet at the outlet) are more likely to have an opportunity to stabilize sediment. The effect also depends on impoundment type, dam size, proximity, age, and other factors.

Vegetated width (1-4-7)—Wetlands with wide stands of vegetation are more likely to stabilize sediments than those with narrow stands. Various researchers found tidal emergent wetlands effective in decreasing wave action when 2 to 10 feet wide and 88% effective when greater than 30 feet wide. Determine average width of vegetated wetland zones. Proportionate width (width relative to channel size) rather than relative width if often a better measure.

Spatially dominant velocity (1-3-5) [typical peak flow velocity through wetland]—Wetlands with flowing water of high velocity will have greater opportunity for stabilizing sediments than those with no flow. Measure is the determination of water velocity throughout most of wetland during peak annual flow.

Substrate type (1-3-5)—Wetlands having no vegetation are likely to stabilize sediment only if they have predominantly rubble substrates. Determine the dominant substrate found in the upper 3 inches of the wetland.

Sediment/Toxicant Retention

Definition. HIGH sediment/toxicant retention areas are those which physically (or chemically in the case of toxicants) trap and retain on a net annual basis the inorganic sediments and/or chemical substances generally toxic to aquatic life.

Effectiveness

Rationale (HIGH). Wetlands with HIGH effectiveness for sediment trapping include ones:

- With no outlets
- That are impounded
- Where WQ sampling indicates outlet waters have less inorganic particulate matter than inlet waters
- Vegetated with erect, persistent vegetation and comprise all of a clearly defined delta, island, bar, or peninsula
- Where there is direct evidence of accretion (photos or field sampling)
- That are depositional environments with erect vegetation wider than 20 feet

Wetlands fulfilling any of these descriptions must also be free of artificial channelization or soil tillage.

Other wetlands qualifying for a HIGH rating are those having most of these conditions:

- Constricted outlet
- No flow or slow-velocity flow
- Brackish salinity
- Riverine with good pool:riffle ratio (if cobble-gravel sediment) or adequate pools and instream debris
- Short fetch
- Great depth (or shallow depths with shorter fetches)
- Relatively long duration and extent of seasonal flooding

Also, these wetlands must be free of artificial channelization or soil tillage as well as having erect vegetation in a zone at least 20 feet wide.

Rationale (LOW). Wetlands that have a low probability of being effective in sediment trapping are one of 5 basic types:

- Wetlands with tilled soils and having a permanent outlet
- Wetlands with cobble-gravel, rubble, or bedrock substrates and no vegetation, instream debris, or pools
- Wetlands fringing the channel immediately downstream from an impoundment
- Wetlands where measured nontidal outputs of inorganic particulate matter are greater than inputs
- Wetlands where the prevailing current velocities are greater than the suspension thresholds of the prevailing sediment types, or
- Wetlands having most of the following characteristics:
    - exposed to boat wakes or channelized
    - unconstructed outlet
    - tilled soil
    - not in a depositional gradient or not being in an AA that expands greatly when flooded
    - shallow depths with large fetch (and minimal aquatic bed vegetation), and
    - minimal fringe vegetation if sediment enters as overland flow (or minimal vegetation interspersion if sediment enters as channel flow)

Wetlands meeting any of the criteria in the paragraph above must also show no evidence of accretion.

General Sensitivity

A majority of prairie pothole wetlands will be rated HIGH, and in some regions a majority of wetlands will be rated MODERATE. Most likely wetlands to be rated LOW will be marine and riverine types. The most pivotal predictors are vegetation zone width, contiguity, flow, velocity, and sediment type.

Opportunity

Wetlands with a HIGH opportunity are those with any of several potential non-point or point sources of sediment or toxicants named in the method (e.g., row crops, steep slope conditions, dumps, fields where pesticides are applied).

Wetlands with a LOW opportunity for sediment and toxicant retention have the absence of sediment sources, a forested watershed of a size not larger than 5x the wetlands area and at least 5% of the upslope watershed being occupied by wetlands (or reservoir being present).

Observational Parameters for Sediment/Toxicant Retention

Climate (1-3-5)—Areas along the Pacific coast, those with high drainage density (miles of stream per square mile), and those with high rainfall erosivity are most likely to have greater transport of sediment and toxicants to wetlands, and thus provide wetlands with the greatest opportunity for retention. Determine whether wetland is located in an intense storm region, an area with high rainfall erosivity factors (greater than 300), or small tidal amplitude.

Watershed/wetland ratio (1-3-5)—Large watersheds (relative to wetland size) are more likely to provide opportunities for this function especially if few wetlands are located in the watershed upstream of the AA. Often suspended sediment loading available to wetlands for retention are correlated with watershed area and storm runoff volume.

Gradient/velocity (1-3-5)—Wetlands with gradual gradients are more likely to perform sediment/toxicant retention than those with steep gradients.

Presence of inlets/outlets (1-3-5)—Wetlands with surface water inlets are more likely to have an opportunity for this function than those without such inlets. Wetlands without outlets are more likely to be effective than those with outlets.

Vegetation class/subclass (1-3-5)—Wetlands dominated by forest, scrub-shrub, or persistent emergent vegetation are more likely to retain sediments and associated toxicants than are unvegetated, moss-lichen, or riverine aquatic bed wetlands. Sedimentation also depends on particle size, gradient, morphology of the wetland's basin, and other factors.

Vegetation/water interspersion (1-4-7)—Wetlands with dense vegetation are more likely to retain sediments and toxicants than those with sparse vegetation. See sediment stabilization for more information.

Fetch/exposure (1-3-5)—Unsheltered wetlands are less likely to retain sediments and toxicants, whereas those such as islands, deltas, bars, or peninsulas, which shelter adjacent areas by intercepting waves, are more likely to retain these.

Watershed land cover (1-4-7)—Wetlands with watersheds dominated by forest or scrub-shrub vegetation are less likely to have an opportunity for sediment/toxicant retention than those with urban, agricultural, or similar land uses. Densely vegetated watersheds (e.g., undisturbed forest, scrub-shrub cover) stabilize soils, reduce runoff velocity, and thus export less sediments.

Sediment sources (1-4-7)—Wetlands that receive runoff from watersheds with erosion-susceptible areas have the greatest opportunity to perform sediment/toxicant retention. Sediments (and associated toxicants) are more likely to wash into wetlands if watersheds have steep slopes, exposed soils, or soils susceptible to erosion. Determine potential sources of sediment and toxicants including storm water outfalls, irrigation return waters, surface mines, exposed soils, erosion-prone soils, gullies, sand or gravel pits, or severely eroding stream or road banks.

Contaminant sources (1-4-7)—Wetlands in the proximity of potential sources of waterborne contaminants are more likely to have an opportunity for sediment/toxicant retention. TMDLs.

Direct alteration (1-3-5)—Wetlands that are tilled or filled or excavated or have had an outlet added or an inlet blocked are less likely to retain sediment and associated toxicants.

Vegetation/water proportions (1-3-5)—Wetlands with mostly open water are less likely to retain sediment and toxicants than those that are extensively vegetated.

Water level controls upstream (1-4-7)—Wetlands not influenced by upslope impoundment are more likely to have opportunity for sediment/toxicant retention, whereas wetlands that experience ponding caused by a downstream pond or dike are more likely to be effective at retaining sediments and associated toxicants.

Water level controls downstream (1-4-7)— Wetlands not influenced by upslope impoundment are more likely to have opportunity for sediment/toxicant retention, whereas wetlands that experience ponding caused by a downstream pond or dike are more likely to be effective at retaining sediments and associated toxicants.

Flooding extent/duration (1-3-5)—Wetlands that experience seasonal flooding of long duration and great extent are more likely to retain sediment and toxicants. With a greater duration and extent, there is more settling time for sediments. Increased productivity (with seasonal flooding) will offer more vegetational resistance allowing for more sedimentation.

Vegetated width (1-4-7)—Wetlands in which average width of PEM, PSS, or PFO vegetation is great are more likely to retain sediment and associated toxicants that where vegetation is narrow. See previous functions for more information to consider.

Spatially dominant velocity--(1-4-7) [typical peak flow velocity through wetland]—Wetlands with predominantly low water velocities during annual peak flows are more likely to retain sediments and toxicants than those with rapid flow.

Wetland depth (spatially dominant) (1-3-5)—shallow wetlands are more likely to retain sediments and toxicants than are deep wetlands as they offer greater frictional resistance, both directly and as a result of their favoring rooted vegetation. May not be a good parameter as wind mixing of substrate in shallow wetlands, thus resuspending sediments and inhibiting burial (especially if wetland is unvegetated).

Substrate type (1-4-7)—Wetlands with predominantly bedrock, rubble, or cobble-gravel substrates are less likely to retain sediment and toxicants than those with mud or organic sediments. Mud and organic matter are usually found in sheltered, depressional areas, whereas the rocky substrates are typical of high-energy, erosional areas. Thus, the greater potential for sediment retention. Toxicant retention is often associated with organic soils.

Salinity (WQ data) (1-3-5)—Wetlands with mixosaline (0.5 to 18.0 ppt) waters are more likely to retain sediment and associated toxicants. Clay particles flocculate and settle out at the fresh/salt water inserface (e.g., mixosaline waters).

Suspended solids (WQ data) (1-4-7)—The greater the level of suspended solids in surface water or runoff, the greater the opportunity for sediment retention.

TSS differential (WQ Data) (1-4-7) [inflow vs. outflow TSS]—Wetlands that show higher levels of TSS at inlet(s) than at outlet(s), then the wetland may be acting as a sink for suspended solids.

Nutrient Removal/Transformation

Definition. HIGH nutrient removal areas are those which retain or transform inorganic phosphorus and/or nitrogen into their organic forms or transform (remove) nitrogen into its gaseous form on a net annual basis or during the growing season.

Effectiveness

Rationale (HIGH). Sediment retention is often accompanied by nutrient retention and vice versa. Thus, conditions conducive to sediment trapping (e.g., presence of inlets with constricted or no outlets) indicate a HIGH probability of nutrient removal/transformation. Alternatively, the presence of <u>most</u> of the following conditions also rates HIGH for this function:

- Low water velocity or presence of significant vegetation
- Fine mineral soils and alkalinity greater than 20mg/l
- High plant diversity with no dead forested or scrub-shrub areas or structures to confine water
- Significant vegetation and nutrient sources, and
- Hydroperiod permanently flooded or saturated

Rationale (LOW). Wetlands are rated LOW for nutrient removal if they are also rated LOW for sediment trapping, plus have peat sediments, anoxic water column conditions, and no woody or floating-leaved vegetation.

Opportunity

Wetlands with a HIGH opportunity are those with any of several potential non-point or point sources of nutrients named in the method (e.g., septic systems, feed lots). Wetlands with a LOW opportunity have the absence of nutrient sources, combined with a forested watershed, or with a watershed less than 5x the wetlands area and having relatively permeable soils.

General Sensitivity

See sediment/toxicant retention above but also consider that prairie potholes and many bottomland/riparian wetlands will rate HIGH for effectiveness, but very few other wetlands will. Most others will be rated MODERATE.

Observational Parameters for Nutrient Removal/Transformation

Climate (1-3-5)—Areas having erosive rainfall are more likely to encourage transport of nutrients to wetlands, and thus their wetlands have an opportunity for nutrient removal/transformation. Nutrients, in addition to soil particles, are removed and transported in the erosion process. Thus, the index (rainfall erosivity factor) reflects the potential of nutrient load of runoff. Erosion and transport also depend on seasonality of rainfall, soil type, gradient, and land cover. Calculate in on-line, via EPA Fact Sheet 3-1, or USDA Handbook 7-3.

Wetland size (1-4-7)—Larger watersheds are more likely to encourage transport of nutrients to wetlands and consequently its wetlands have more of an opportunity for nutrient removal/transformation. This is because the larger the watershed, the greater the source area and erosion potential for nutrients in runoff. The relationship of nutrient delivery to watershed area in agricultural watersheds is nonlinear, with nutrient delivery per unit area decreasing in larger watersheds. Land cover type, proximity to wetland , slope, and soil type are also important. [**Note:** WET uses watershed size, while Carney 2002used wetland size.]

Watershed/wetland ratio (1-4-7)—Large watersheds (relative to wetland size) have a greater opportunity for nutrient removal/transformation, especially if few other wetlands are located upslope from the AA.

Gradient (1-3-5)—Wetlands with gradual gradients are more likely to retain or transform nutrients than those with steep gradients.

Presence of inlets/outlets (1-3-5)—Wetlands with permanent inlets have a greater opportunity for nutrient removal/transformation than do those without inlets, whereas those with not outlets are more effective at nutrient removal/transformation.

Vegetation class/subclass (1-3-5)—Wetlands with predominantly forested, scrub-shrub, floating vascular aquatic bed, or persistent emergent vegetative cover are more likely to remove or transform nutrients, whereas those with moss-lichen dominant cover are less likely to perform this function. It is likely that dense PFO and PSS wetlands perform this function the best as they slow down runoff and flow, may retain nutrients long term in woody tissues, etc. However, frequently flooded woody riverine wetlands typically support more widely spaced vegetation.PEM wetlands perform this function well but may only retain nutrients seasonally. AB vegetation is less effective as it is not persistent enough to slow down flow and has shallow roots that cannot penetrate and oxidize the underlying sediment.

Vegetation form richness (1-3-5)—Wetlands with high vegetation form richness are more likely to perform nutrient removal/transformation more effectively. The greater number of plant forms (trees, shrubs, persistent/non persistent emergent, floating, and submersed vegetation the better as each retains and transforms nutrients differently.

Watershed land cover (1-4-7)—Wetlands having watersheds with predominantly forest or scrub-shrub cover are less likely to receive nutrients from upslope drainage, and therefore have less opportunities to perform this function than those with watersheds dominated by impervious, agricultural fields, or exposed soils. Nutrient loadings and sediment amounts reaching these wetland are less.

Presence of ditches/channels (1-3-5)—Wetlands with ditches, channels, etc. that cause surface water to leave at a faster rate than normally would occur are less likely to remove or transform nutrients than those wetlands without such modifications.

Soil permeability (1-3-5)—Wetlands with predominantly fine mineral sediments (e.g., alfisols, clays) or those sediments containing high levels of aluminum or iron are more likely to remove or transform nutrients, especially phosphorus. See Volume 1 of WET for more details.

Nutrient sources (1-4-7)—Wetlands that receive major discharge from nutrient-rich sources (sewage outfalls, phosphate mines, feedlots, pastureland, landfills, eroding stream banks, fertilized soils, or soils that have been tilled, burned or recently cleared provide a greater opportunity for nutrient removal/transformation than those without such sources.

Direct alterations (1-4-7)—Wetlands that have been tilled, filled, or excavated, or those that have had an outlet added or inlet blocked, are less likely to remove and/or transform nutrients.

Most permanent hydroperiod (1-3-5)—Wetlands that are permanently flooded or saturated are more likely to perform nutrient removal/transformation because wetlands with constantly (or nearly so) saturated substrates tend to retain nutrients. Anaerobic conditions favor the retention of phosphorus and nitrogen. See Volume 1 of WET for more information.

Vegetated width (1-4-7)—Wetlands with wide stands of vegetation (primarily wooded or emergent) are more likely to remove/transform nutrients given that these wetlands slow flow enhancing nutrient removal by sedimentation and burial. Removal is best at shallow depths (1.2 to 3m) where vegetation occurs. Wetlands with length-to-width ratios of more than 3.0 (parallel to flow) are more likely to remove nutrients (greater residence times).Vegetation type, soil type, and diffusion pattern are also important and interact with wetland width.

Spatially dominant velocity--(1-4-7) [typical peak flow velocity through wetland]—Wetlands with low flow velocities are more likely to remove and/or transform nutrients that are those with high flow velocities.

TDS/total alkalinity (WQ Data) (1-3-5)—Wetlands having waters with low alkalinity levels (< 20mg/l calcium carbonate) are less likely to remove or transform nutrients (excluding nitrogen). Phosphates can be precipitated with calcium.

Production Export

Definition. HIGH production export is the flushing of relatively large amounts of organic plant material (specifically, net annual production) from the AA into downslope waters.

Effectiveness

Rationale (HIGH). To attain a HIGH rating, the AA must have conditions favorable to primary productivity and have a permanent outlet. Specifically, for a riverine wetland system, the following conditions must be present:

- Potentially eutrophic conditions present
- Watershed greater than 100 square miles, and
- Significant areas of erect or submerged vegetation present.

If lacustrine, required conditions must include:

- Significant areas of erect vegetation present
- Aquatic or emergent vegetation dominate the AA
- Plant productivity high
- pH not acidic
- Potential for eutrophic conditions or existing high levels of dissolved solids
- High erosion potential, and
- Watershed not small

For a palustine wetland system, the following conditions must be present:

- Significant areas of erect vegetation present
- Potential erosive conditions
- Zone B greater than 10% of AA
- Potential for expansive flooding
- Potential for eutrophic conditions or existing high levels of dissolved solids
- Plant productivity high, and
- Fringe or island situation.

In addition, for ALL wetland systems, one of the following conditions must not be present:

- Moss-lichen class extensive
- Sandy substrate
- Water velocity high or AA unsheltered
- Low water/vegetation interspersion
- Presence of direct alteration
- Artificially manipulated water levels
- Small watershed, or
- Low levels of suspended solids.

Rationale (LOW). For a LOW rating, the AA must not have permanent or intermittent outlets regardless of the productivity levels present (e.g., low relative probability of exporting organic nutrients). Some wetlands with outlets may be rated LOW if reduced macrophyte productivity is suggested by

- A sand bottom dominating in a flowing water situation with very little stable instream substrates
- The occurrence of recent soil disturbance, headwater situation without emergent or aquatic bed vegetation
- Scouring conditions of current or fetch with no offsetting influence of aquatic vegetation, or
- Excessive turbidity in an aquatic bed-dominated wetland.

General Sensitivity
Non-contiguous wetlands and non-tidal riverine wetlands (excluding some fringe types, such as bottomland hardwoods) will generally get lower ratings for this function. Most contiguous palustrine wetlands will probably be rated HIGH. The most pivotal characteristics appear to be contiguity, system type, fringe situation, and velocity.

Observational Parameters for Production Export

Climate (1-3-5)—Wetlands located in intense storm regions or those with erosive rainfall are more likely to export production. Are our AAs located in an intense storm region (Kansas is) or do they have rainfall erosivity factors greater than 300? No to the latter and probably yes to the former.

Watershed size (1-3-5)—Wetlands with proportionately large watersheds are more likely to export production (at least up to a stream order 5). Also, the larger the watershed the greater the runoff.

Wetland size (1-3-5)—Larger wetlands are more likely to export production. Determine acreage of the wetland in question and any wetland within 1 mile that are connected by surface water. The 5-acre threshold is arbitrary.

Watershed/wetland ratio (1-2-3)—Wetlands that comprise a large portion of their watershed are more likely to export significant quantities of their production downstream. The 20-percent threshold is arbitrary.

Gradient (1-3-5)—Wetlands with steep gradients are more likely to export production than are those with gradual gradients.

Presence of inlets/outlets (1-4-7)—Wetlands with outlets are more likely to export their production than those without outlets. There must be at least an intermittent connection to other areas (downstream). Presence of an inlet as well suggests better flushing, and thus, at least for PFO wetlands, higher production.

Fringing wetland (1-4-7)—Fringe wetlands are more likely to export their production than are nonfringe wetlands.

Vegetation class/subclass (1-4-7)—Wetlands dominated by moss-lichen vegetation are less likely to export production. Of the remaining vegetation classes, areas dominated by PFO and PSS vegetation are less likely to have large amounts of production available for export than are those dominated by PEM or PAB vegetation. The 1-acre and 10-percent thresholds are arbitrary.

Vegetation interspersion (1-3-5)—Wetlands with a high degree of vegetation-water interspersion are more likely to export their production than those with very sparse or extremely dense vegetation.

Sheet vs. channel flow (1-4-7)—Wetlands in which flow occurs mostly as sheet flow are more likely to export their production than are those with predominantly channel flow as the greater degree of contact between vegetation and moving water, the greater the potential for production export.

Fetch/exposure (1-3-5)—Wetlands that are moderately sheltered are more likely to export production than are those well sheltered or extremely exposed. Within limits, the greater the fetch, the greater the wave energy, vertical mixing, and potential export of organic materials and associated nutrients. Determine the fetch and area sheltered by vegetation or topographic relief.

Flow/scour potential (1-3-5)—Wetlands that have flows sufficient to moderately or seasonally scour the wetland are more likely to export their production than are those that are either not scoured or are severely scoured. Occasional scouring thins stands of wetland plants, thus enhancing circulation, reproductive vigor, and productivity. However, severe and frequent scouring can denude wetlands for long periods, resulting in decreased production, and consequently decreased production export.

Direct alterations (1-3-5)—Unaltered wetlands are more likely to have greater production and more useful export regimes than those altered by tilling, filling, excavation, adding outlets, or blocking inlets. Has there been any ground disturbance in the last three years or so?

Water/vegetation proportions (1-3-5)—Estuarine, marine, palustrine, or lacustrine wetlands with at least 10 percent of their total area covered by visible, standing, surface water are more likely to export production. Riverine wetlands in which the area of aquatic bed vegetation is larger than the unvegetated submerged areas are more likely to export production. Wetlands must be flooded for there to be effective above ground production export.

Water level controls (1-3-5)—Wetlands without artificial water control structures are more likely to export production than those with such structures.

Flooding extent/duration (1-3-5)—Wetlands where the extent and duration of flooding are intermediate are more likely to export production. Seasonal flooding enhances the decomposition and export of detritus, and increases the access of consumer organisms to this potential food source, thus further enhancing its dispersal. Also, the productivity of PFO and PEM wetlands is often greater where they are seasonally flooded rather than permanently flooded.

Vegetated width (1-3-5)—Wetlands with the average width of the area dominated by emergent, shrubby, or forested vegetation is greater than 20 feet are more likely to export production than with lesser widths. The 20-foot width is arbitrary according to the manual.

Spatially dominant velocity--(1-4-7) [typical peak flow velocity through wetland]—Wetlands in which flow is moderate are more likely to have useful regimes of exporting production than those in which flow is either slow or very rapid. See Volume I (page 147) for additional details.

Substrate type (1-3-5)—Wetlands containing a substrate type other than sand are more likely to export production. Primary production is usually low on sand (and sometimes cobble-gravel) because of low nutrient availability and instability. What is the dominant surface substrate in the wetland?

Plant productivity (1-4-7)—Wetlands with high primary productivity are more likely to export production. So, how do the wetlands rate in our region. PFO>PSS>PEM>PAB depending on density, cover, and the like?

pH (WQ data) (1-4-7)—Wetlands where the pH is circumneutral (6.0 to 8.5) are more likely to support substantial production than are those with more acidic or alkaline values. Productivity of vascular plants is greater at circumneutral values, so more material is available for export. Low pH waters have lower decomposition rates and less fish. Higher pH (6.0 to 8.5) generally results in better buffering and higher productivity.

Suspended solids (WQ data) (1-3-5)—Wetlands having lower suspended solids concentrations are more likely to support sufficient production for eventual export. Turbidity reduces light penetration and consequently primary productivity (at least among algae and submersed aquatic bed species.

TDS/total alkalinity (WQ data) (1-3-5)—Inland wetlands with moderate alkalinity levels are more likely to support greater primary productivity and thus have more production available for export. Determination of alkalinity ($CaCO_3$) levels and the morphedaphic index (Ryder 1965) in relation to threshold levels. The 20-mg/l threshold for alkalinity is similar to several state WQ levels. Kansas?

Eutrophic condition (WQ data) (1-3-5)—Wetlands with moderate or high nutrient levels and loading rates are more likely to sustain higher production for eventual export. See Volume I, pp. 150-152 for additional information.

Aquatic Diversity/Abundance

Definition. A HIGH rating for an AA means that at least seasonally the AA supports a notably great on-site diversity of fish or invertebrates that are mainly confined to the water and saturated soils.

Effectiveness

Rationale (LOW). Before being rated HIGH, the wetland must not be rated LOW. Riverine (and estuarine) wetlands cannot have a bedrock or rubble substrate without substantial macroalgae, nor have potentially toxic inputs into an AA that lacks an outlet and is less than 40 acres. Lacustrine and palustrine wetlands also must lack these conditions, and also must not be farmed, must have some surface water, and must not have an excessively acidic condition.

Rationale (HIGH). If the wetland does not meet the conditions necessary to receive a LOW probability, a majority (not all) of several conditions must be present for a HIGH probability rating.

If riverine, the hydroperiod must be 'regularly flooded' and such areas must comprise at least 10% of the AA, must not be dominated by sand, and must have a diversity of depths and current velocities. In addition, wetlands must

- Not be channelized, leveed, or have seasonal timing of their flows altered
- Have minimal natural variation in flow (suggesting groundwater inputs)
- Have stream banks that are not completely forested or totally unshaded

- Have adequate instream cover dissolved oxygen, and adequate pools in headwater and intermittent streams

If lacustrine, the AA should:

- Have an inlet and outlet
- Be larger than 200 acres or, if smaller and in an ice-hazard region, have a large watershed
- Not be dominated by a sand bottom
- Be permanently flooded (at least in part)
- Have a shallow area with diverse cover and vegetation that covers at least 10% of the area of the deep water
- Have a diversity of depth categories and adequate dissolved oxygen
- Not be leveed or ditched
- Expand substantially with natural seasonal flooding, and
- Not be oligotrophic or should have suitable values for the morphedaphic index.

If palustrine, (in addition to the lacustrine characteristics above) the wetland:

- Should have moderate amounts of erect vegetationignificant areas of erect vegetation well juxtaposed with open water
- If forested, should have some flow present throughout
- Should not have its water levels subject to artificial manipulation (except for intentional ecological management)
- Potential for expansive flooding

General Sensitivity
Minimal wetlands will be assigned a LOW rating. Palustrine wetlands may be slightly lower than lacustrine ones to attain a HIGH rating. The most pivotal characteristics are substrate, hydroperiod, and presence of potential toxicants.

Observational Parameters for Aquatic Diversity/Abundance

Climate (1-3-5)—Lacustrine and palustrine wetlands that remain unfrozen for more than 1 month during most winters are likely to have a relatively great on-site diversity and/or abundance of fish and invertebrates.

Wetland area (1-3-5)—Wetlands larger than 40 acres (including unconstricted contiguous waters) are more likely to exhibit great fish and invertebrate diversity and/or abundance than small wetlands.

Watershed area (1-3-5)—Wetlands that are located near large water bodies, or within large watersheds are more likely to provide a notably great on-site diversity and/or abundance of fish and invertebrates. Note: The author had a low confidence in this parameter and its measure. Richness generally appears to increase the most between stream orders 3 and 4 and the 100-square mile threshold for watershed size is a crude approximation of the acreage typically associated with this transition. Other factors are also important including human disturbance, land cover changes, and increased prevalence of exotics downstream.

Watershed/wetland ratio (1-3-5)—Wetlands located in watersheds with many other wetlands are more likely to have greater on-site diversity and or abundance of fish and invertebrates. The 5-percent watershed for upslope wetlands in the watershed is arbitrary.

Presence of inlets/outlets (1-3-5)—Wetlands with the highest to lowest probabilities for supporting great on-site diversity and/or abundance of fish and invertebrates if the wetland has 1) both an inlet and outlet, 2) either one or the other, and 3) no inlet or outlet.

Fringing wetland (1-2-3)—Lacustrine and palustrine wetlands that form at least a part of a fringe wetland or island are more likely to a have a great on-site diversity and/or abundance of fish and invertebrates than the opposite. Fringe wetlands are at the interface between terrestrial and aquatic communities where both density and diversity of species are high.

Vegetation class/subclass (1-4-7)—Wetlands dominated by aquatic bed vegetation are more likely to have a great on-site diversity and/or abundance of fish and invertebrates. Densities of invertebrates often greater in PABs than in PEMs probably due to the greater surface area of the dissected leaves of submerged leaves. Algae-dominated wetlands may have exceptionally high diversity and productivity of invertebrates. Also, green algae or diatoms can provide a highly palatable food for consumers. Freshwater PFOs seldomly compared to PAB and PEM, but density and species richness great at the outer surface water edge in FW wooded systems for both invertebrates and fish. Among PFOs, deciduous broad-leaved wetlands (especially alder and willow species) produce particularly great amounts for detritus especially desired by consumers. Note: the extent and density of vegetation or detritus are probably more important than wetland type.

Vegetation/water interspersion (1-3-5)—this function depends on two factors: 1) the amount of interspersion of vegetation present and 2) the way in which water enters the wetland. Wetlands that contain vegetation interspersed with open water are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates. In other words, those with very dense vegetation and no channels or open water area are less likely to support this function.

Sheet vs. channel flow (1-3-5)—Wetlands where water enters in a channel and spreads out over a wide open area under average flow conditions have on-site diversity and/or abundance of fish and invertebrates. In other words, an even distribution of water throughout a wetland provides an optimal opportunity of shelter from predators, complex substrates for attachment or feeding, and ample exchange of dissolved oxygen and nutrients.

Vegetation class interspersion (1-3-5)—Wetlands with intermediate or high vegetation class interspersion have a great on-site diversity and/or abundance of fish and invertebrates. Wetlands that contain an interspersed mosaic of different vegetation classes provide a greater variety of food, shelter, and other habitat requirements. In palustrine wetlands, invertebrate richness is greatest where aquatic bed and emergent classes are interspersed.

Vegetation form richness (1-4-7)—Wetlands that contain numerous vegetation forms in relatively even proportions are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates. See citations in Volume I, pages 160 and 161.

Shape of wetland edge (1-2-3)—Wetlands with irregular or sinuous wetland-upland edges are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates than are those with smooth, regular edges. This is due to the potential augmentation of habitat structure, providing shelter and enhancing diversity of the open water-wetland plant edge.

Vegetation canopy (1-4-7)—Riverine wetlands with sufficient vegetation or topographic relief on adjacent banks to provide moderate shade to much of the wetland at midday are more likely to support notably great on-site diversity and/or abundance of fish and invertebrates.

Watershed land cover (1-4-7)—Wetlands in watersheds dominated by impervious surfaces are less likely to support a notably great on-site diversity and/or abundance of fish and invertebrates. Greater impervious surface upslope can cause unnatural, accelerated runoff, aberrant wetland hydroperiods, and higher levels of sediment and toxicants in wetlands.

Presence of ditches/channels (1-3-5)—Wetlands without functioning ditches, canals, levees, or similar artificial features that cause water to leave faster than would occur naturally are more likely to have great on-site diversity and/or abundance of fish and invertebrates than those with such structures. See pages 163 and 164 in Volume I for additional information.

Sediment sources (1-3-5)—Wetlands without sources of inorganic sediment or those that do not frequently experience activity (e.g., boating) that causes sediment resuspension are more likely to exhibit a great on-site diversity and/or abundance of fish and invertebrates.

Contaminant sources (1-4-7)—Wetlands without waterborne contaminants or sources that potentially contribute such contaminants are more likely to have a notably great on-site diversity and/or abundance of fish and invertebrates.

Direct alteration (1-3-5)—Unaltered wetlands are more likely to exhibit a notably great on-site diversity and/or abundance of fish and invertebrates than those that have been altered by tilling, filling, excavation, addition of inlets, or blockage of outlets.

Water/vegetation proportions (1-4-7)—Wetlands that have moderate amounts of their total area covered by unvegetated surface area are more likely to exhibit great on-site diversity and/or abundance of fish and invertebrates. See vegetation-interspersion above.

Spatially dominant hydroperiod (1-3-5)—Rankings for this predictor depend on the wetland system. Riverine wetlands that are seasonally or permanently flooded are more likely to have a great on-site diversity and/or abundance of fish and invertebrates. The greater amount of aquatic habitat the greater the abundance of fish and invertebrates relatively speaking.

Water level controls (1-3-5)—Wetlands with drastic artificial water-level fluctuations are less likely support a notably great on-site diversity of fish and invertebrates.

Flooding extent/duration (1-4-7)—Wetlands that experience seasonal flooding of large extent and duration are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates.

Substrate type (1-3-5)—Palustrine, lacustrine, and riverine wetlands with sand substrates are less likely than other wetland types to support a notably great on-site diversity and/or abundance of fish and invertebrates. Organic sediments such as peat and muck, which are usually more prevalent in vegetated aquatic areas than in nearby unvegetated bottoms, generally have greater densities of fish and aquatic invertebrates.

Physical habitat interspersion (1-4-7)—Wetlands that contain a mosaic of substrate types, velocities, and depths are more likely to have greater on-site diversity and/or abundance of fish and invertebrates.

Aquatic habitat depths (1-4-7)—Riverine wetlands containing relatively equal proportions of pools (or backwater sloughts) and riffles are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates.

pH (WQ data) (1-3-5)—Wetlands in which the pH is curcumneutral (pH of 5.6 to 8.6) are more likely to support a greater on-site diversity and/or abundance of fish and invertebrates.

Salinity (WQ data) (1-3-5)—Lacustrine/palustrine wetlands that have salinities less than 5 ppt are more likely to have a great on-site diversity and/or abundance of fish and invertebrates. Generally dominant species in lacustrine, palustrine, and riverine wetlands cannot survive salinities greater than 5 ppt.

Suspended solids (WQ data) (1-3-5)—Wetlands that receive runoff or surface waters with low levels of SS (especially inorganic) (usually less than 80 mg/l and never exceeding 200 mg/l) are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates. See pages 175 and 176 in Volume I for more details.

TDS/total alkalinity (WQ data) (1-4-7)—Wetlands with low (less than 20 mg/l $CaCO_3$) alkalinity are less likely to support this function. Also, wetlands with either low (less than 7) or high (greater than 35) morpedaphic indices (total dissolve solids/mean depth) are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates.

Eutrophic condition (WQ data) (1-3-5)—Oligotrophic wetlands are less likely to support a notably great on-site diversity and/or abundance of fish and invertebrates. Necessary to determine water nutrient levels or their indicators in relation to threshold levels. Check TMDLs for the specific streams and their watersheds.

Dissolved oxygen (WQ data) (1-4-7)—Wetlands where dissolved oxygen concentrations are greater than 4 mg/l and 60 percent saturation are more likely to support a notably great on-site diversity and/or abundance of fish and invertebrates.

Wildlife Diversity/Abundance

Definition. A HIGH rating for a wetland means that (during the breeding season) the wetland normally supports a notably great on-site diversity and/or abundance of wetland-dependent birds. Off-site contribution of AA to faunal richness, etc. is not taken into consideration.

Effectiveness

Rationale (Level 2--HIGH). There are 6 types of wetlands that have a high probability of supporting an exception diversity of breeding birds including certain individual wetlands of the following:

- Non-wooded prairie potholes
- Western riparian zones
- Bottomland hardwoods
- Other floodplain wetlands
- Large and vegetationally diverse wetlands
- Moderate-sized wetlands that are oases or complexes and have at least minimal dispersion.

Accuracy in the use of this key depends on reliable estimation of the following characteristics:

- Surrounding land use
- Potential sources of toxic material
- Location is a precipitation deficit area
- Interspersion size, and
- Vegetation class

Rationale (Level 2--LOW). There are 7 wetlands, which, in a natural context, have a LOW probability of supporting exceptional diversity of breeding birds. Certain individual wetlands within the following 7 types may be rated LOW if they are in a precipitation surplus region:

- Upper riverine, forested, shrub, or moss wetlands unconnected to adjoining forests by vegetated corridors, and smaller than 40 acres
- Small wetlands with potential toxic inputs
- Palustrine/lacustrine wetlands that either are
    - Predominantly moss (peat bogs), and have low vegetation class diversity, and not open water or
    - Small, surrounded by urban development, and have no connecting corridors (if forested)
    - Small, and have low vegetation class diversity, low edge irregularity, no open water, and are not part of an oasis/cluster.

Accuracy in the use of this key depends on reliable estimation of the following characteristics:

- Location is a precipitation surplus area
- Size
- Potential sources of toxic material, and
- Wetland classification

Rationale (Level 2—HIGH and LOW). Improved estimates from Level 2 due to in-field determinations of dominant hydroperiod, the hydroperiods of nearby wetlands, general salinity, presence or absence of certain alterations of hydrology and soils, and flow velocity. 'Disturbance' is substituted for 'urban watershed,' as it more directly measures stress to wildlife. In addition to the requirements of Level 2, the following characteristics must be present to achieve a HIGH rating:

- Hydroperiod that is not saturated or intermittently flooded unless evapotranspiration is more than twice precipitation

- Salinity less than 30 ppt
- Velocity, if riverine, less than 30 cm/sec
- Hydric soils that have not been tilled, nor any type of detrimental hydrologic alterations made.

In addition, a seventh type of wetland is added to the 6 Level 2 wetlands: artificially flooded wetland managed for wildlife management.

To attain a LOW rating under Level 3, the converse of the above must be true. Also, for wetlands smaller than 5 acres, Zone A must be larger than Zone B.

Observational Parameters for Wildlife Diversity/Abundance

Climate (1-3-5)—Wetlands in areas where evaporation exceeds precipitation (i.e., precipitation deficit like Kansas) are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds.

Wetland size (1-3-5)— Larger wetlands (or those directly connected to larger water bodies or tracts of suitable undeveloped habitat) are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds than smaller wetlands. The 5-acre minimum threshold is arbitrary. See pages 179-180 in Volume I for more details.

Complex, cluster, or oasis (1-4-7)—A wetland that is the only wetland within a wide area (an oasis), or is part of a dense regional cluster or complex (or is singularly very large) is more likely to exhibit notable on-site diversity and/or abundance of wetland-dependent birds. Sizes and thresholds are arbitrary. See pages 180-181 in Volume I for more details.

Watershed size (1-3-5)—Wetlands with larger watersheds are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds than smaller wetlands because these wetlands are more likely to persist than those in smaller watersheds. Also, larger watersheds provide a greater source area for nutrients to the wetland, perhaps making the wetland more productive.

Gradient (1-2-3)—Wetlands with lower gradients are more likely to exhibit a notable on-site diversity and/or abundance of wetland-dependent birds. Factor deals with water velocities increasing with greater gradients, keeping sediments in suspension, limiting wetland establishment and reducing the availability of food organisms.

Presence of inlets/outlets (1-2-3)—Wetlands with permanent outlets are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds than are wetlands without permanent outlets as wetlands without outlets tend to concentrate toxicants when present. Of course, some prairie pothole wetlands are exceptionally productive and critical to wildlife.

Vegetation class/subclass (1-4-7)—Wetlands dominated by forested or scrub-shrub vegetation are more likely to support a notable on-site diversity and/or abundance of migrating and wintering wetland-dependent birds as a result of more habitat structure through vertical layering and increased patchiness from horizontal overlap of layers. Consequently, these areas can support a wider species diversity than vegetation forms that are less complex. See page 184 in Volume I for more information.

Vegetation/water interspersion (1-4-7)—Wetlands with good vegetation-interspersion are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. The greater interspersion is important because of the resultant increased variety of vegetation types and cover conditions.

Vegetation class interspersion (1-4-7)—Wetlands with well interspersed vegetation classes are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds. Most species require several different cover types in one area to meet requirements for food, shelter, nesting, loafing, and protection from predators, so the less energy expended in moving from one cover type to another, the more suitable the area. Determine the horizontal pattern of vegetation class interspersion.

Plant form richness (1-4-7)—Wetlands with numerous well interspersed vegetation forms are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds. Determine the number of vegetation classes and subclasses found in the wetland. All thresholds are arbitrary. See page 187 in Volume I for more explanation.

Shape of wetland edge (1-3-5)—Wetlands in which the wetland-upland edge is irregular are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. The greater sinuosity or irregular shape are more likely to have a greater interspersion of cover types and more edge.

Fetch/exposure (1-3-5)—Sheltered wetlands are more likely to support a notable on-site diversity and/or abundance of breeding and wintering wetland-dependent birds. Determine the fetch and whether at least 1 acre of the wetland is sheltered.

Watershed land cover (1-4-7)—Wetlands having watersheds not dominated by impervious surfaces are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds. During migration and wintering, wetlands with watersheds dominated by cultivated agricultural areas are more likely to provide such diversity and/or abundance. See pages 189-190 in Volume I for more information.

Presence of ditches/channels (1-3-5)—Wetlands without artificial structures that increase the flow of surface water from the wetlands are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. Obviously, draining a wetland precludes its use by wetland-dependent species.

Contaminent sources (1-4-7)—Wetlands free of potential sources of toxic material are more likely to support a notable on-site diversity and/or abundance of breeding wetland-dependent birds. Not a bad idea to have the list of TMDLs for each watershed and stream in which least impacted wetlands occur.

Direct alterations (1-4-7)—Unaltered wetlands are more likely to exhibit a notably great on-site diversity and/or abundance of wetland-dependent birds than those that have been altered by tilling, filling, excavation, addition of inlets, or blockage of outlets.

Disturbance sources (1-3-5)—Wetlands without major, frequent disturbances are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. Human disturbances include hunting, walking, and boating, which alter bird flights, increase bird movements during feeding all of which reduce energy reserves of wintering/migrating birds. Trampling and fire can alter important habitat, too.

Water/vegetation proportions (1-4-7)—Wetlands with relatively even proportions of vegetation and water are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds, primarily waterfowl. Literature noted 50:50 ratios of water to well-interspersed cover provided increased densities of dabbling duck pairs and maximum species richness and abundance of birds. In another study, marshes with 50 to 70 percent open water well interspersed with emergent vegetation produced greatest bird diversities and numbers.

Spatially dominant hydroperiod (1-3-5)—Wetlands in which at least a portion is permanently flooded or intermittently exposed are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. These need not be the spatially dominant hydroperiods of the wetland. These hydrologic conditions can provide a wide variety of habitat types ranging from open water to vegetation adapted to moist soil conditions. Also, it may provide refugia during periods of drought. Wetlands whose spatially dominant hydroperiod is 'artificially flooded nontidal' are more likely to support a notable on-site diversity and/or abundance of migrating and wintering wetland-dependent birds. These areas are likely to be productive especially if greater than 1 acre, not long and narrow, and are drawn down and flushed of excessive sediment, organic matter, and salts every few years. <u>Note</u>: in the prairie region the greatest density of breeding birds occurs in semipermanent wetlands. See pages 194 and 195 in Volume I for more explanation.

Most permanent hydroperiod (1-3-5)—Wetlands having areas of at least 1 acre or 10 percent of their area that is permanently flooded or intermittently exposed as their most permanent hydroperiod are more likely to support a notably great on-site diversity and/or abundance of wetland-dependent birds. Greater variety of habitats are found with such a hydrologic regime. Also, emergent wetland plants need periodic drawdowns (i.e., shallow water or mud flats) in order to germinate.

Water level controls (1-4-7)—Wetlands dependent upon upstream or downstream control structures (other than those designed specifically for fist and wildlife management) are <u>less</u> likely to support a notably great on-site diversity and/or abundance of migrating and wintering wetland-dependent birds. These wetlands may be subject to large, sudden water level fluctuations, which are likely to have detrimental impacts on habitats used by migrating and wintering wildlife (but not in the winter most likely). [**Note:** Those designed specifically for fish and wildlife management are <u>excluded</u> from this predictor.]

Vegetated width (1-3-5)—Wetlands with greater vegetated widths are more likely to support a notably great on-site diversity and/or abundance of breeding wetland-dependent birds. The 20- and 500-foot thresholds are arbitrary.

Wetland type combinations (1-4-7)—Wetlands that are near wetlands of a different classification are more likely to support notable on-site diversity and/or abundance of wetland-dependent birds. See pages 197 and 198 of Volume I for more details.

Special habitat features (1-4-7)—Wetlands containing special habitat features such as standing snags with cavities larger than 2 inches; trees with diameters greater than 10 inches; plants bearing fleshy fruits, mast, or cones; tilled land with waste grain; evergreen tree stands with over 80 percent canopy closure; native prairie; or exposed bars are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds that those without these features.

Spatially dominant velocity (1-2-3) [typical peak flow velocity through wetland]—Wetlands with slow flow velocities are more likely to support a notable on-site diversity and/or abundance of breeding wetland-dependent birds.

Substrate type (1-4-7)—Wetlands having substrates other than bedrock, rubble, or cobble-gravel are more likely to support a notable on-site diversity and/or abundance of wetland-dependent birds. Sufficient vegetation to provide food and cover for a diversity of avian species only grows on mineral, peat, muck, and sandy soils.

Plants with waterfowl value (1-4-7)—Wetlands containing food plants preferred by waterfowl (e.g., smartweed species) are more likely to support a notably great on-site diversity and/or abundance of migrating and wintering wetland-dependent birds. Document of preferred waterfowl food plants covering at least 10 percent or 1 acre of wetland. Thresholds are arbitrary. Food plants include spikerush, umbrella sedges, smartweeds, curly dock, beggar ticks, rice cut grass, crabgrass, sprangle top, panic grasses, etc.

pH (WQ data) (1-3-5)—Wetlands with generally curcumneutral to alkaline (pH>6.0) waters are more likely to support a notable on-site diversity and/or abundance of migrating and wintering wetland-dependent birds.

Salinity (WQ data) (1-4-7)—Wetlands with salinities less than 30 ppt are more likely to support a notably great diversity and/or abundance of breeding wetland-dependent birds.

General Recreation Use and Value

Recreation includes consumptive (e.g., sport fishing, food gathering, and hunting) and non-consumptive (e.g., swimming, canoeing, kayaking, and birding). Very little guidance is provided in the manuals, so much like Carney 2002 we'll use our own judgment on rating the different observational parameters.

Observational Parameters for General Recreation Use/Value

Facilities/access (1-4-7)

Presence of other wetlands (1-4-7)

Proximity to public (1-4-7)

Sediment/toxicant retention score (1-4-7)

Nutrient removal/transformation score (1-4-7)

Aquatic diversity/abundance score (1-4-7)

Wildlife diversity/abundance score (1-4-7)

Wetland size (1-4-7)

Flooding extent/duration (1-4-7)

Aesthetic/cultural/heritage score (1-4-7)

Aesthetic/Cultural/Heritage Use/Value

Uniqueness/heritage includes the use of wetlands for aesthetic enjoyment, nature study, education, scientific research, open space, preservation of rare or endemic species, protection of archaeologically or geologically unique features, maintenance of historic sites, etc. Very little guidance is provided in the manuals, so much like Carney 2002 we'll use our own judgment on rating the different observational parameters.

Observational Parameters for Aesthetic/Cultural/Heritage Use/Value

T&E habitat, special designations (1-4-7)

Documented archaeological sites (1-4-7)

Watershed/local land use, landscape (1-4-7)

Vegetation/water interspersion (1-4-7)

Water/vegetation proportions (1-4-7)

Vegetation class interspersion (1-4-7)

Vegetation form richness (1-4-7)

Direct alteration (1-4-7)

Water level controls (1-4-7)

Plant productivity (1-4-7)

Physical habitat diversity (1-4-7)

Aquatic diversity/abundance score (1-4-7)

Wildlife diversity/abundance score (1-4-7)

Sensual stimuli (1-4-7) [visual, aural, olfactory]

Intellectual/emotional interest (1-4-7) [vistas, opportunities for education use]

Trophic status (WQ data) (1-4-7)